DOCUMENT RESUME

ED 399 876 HE 029 511

AUTHOR Goldberg, Julie L.; Sedlacek, William E.
TITLE Summer Study in Engineering for High School Women.
INSTITUTION Maryland Univ., College Park. Counseling Center.
SPONS AGENCY Maryland Univ., College Park. A. James Clark School of Engineering.
REPORT NO UMCP-RR-16-95
PUB DATE 95
NOTE 19p.; Also supported by the Maryland Space Grant Consortium.
PUB TYPE Reports - Descriptive (141) -- Reports - Evaluative/Feasibility (142)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Career Choice; Career Exploration; College Bound Students; College Preparation; *College School Cooperation; *Engineering Education; Females; Higher Education; High Schools; High School Students; Residential Programs; Social Support Groups; State Universities; *Summer Science Programs; *Womens Education
IDENTIFIERS *University of Maryland College Park

ABSTRACT

The transition between high school and college is a crucial point where many young women engaged in the applied sciences and engineering cease their participation. To help retain young women's interest and help bridge the gap between secondary school and higher education, The University of Maryland, College Park, held a six-week live-in academic summer program to expose 30 young women to college-level engineering study. The young women, who had completed their junior year in high school, were enrolled in two college-level introductory engineering courses. The program also included hands-on team design projects; field trips; laboratory work; computer classes; problem solving; working with others; and presentations by female role models. Parents were invited to participate through visits to the campus and attendance at selected orientation and student design presentations. At a focus group in the fourth week of the program, students discussed their level of interest in engineering compared with their interest at the beginning of the program, what they found most valuable about the program, and suggested improvements. Upon successful completion of the program, students earned six credits towards a college degree. (MAH)

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Summer Study in Engineering for High School Women

Julie L. Goldberg and William E. Sedlacek

Research Report #16-95

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This program was funded by the A. James Clark School of Engineering and the Maryland Space Grant Consortium

Counseling Center
University of Maryland at College Park
College Park, Maryland

Summary in Engineering for High School Women

Julie L. Goldberg and William E. Sedlacek

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Summary

Since 1975, the A. James Clark School of Engineering at the University of Maryland at College Park (UMCP) has offered a six-week academic summer program for female high school students interested in engineering. In the summer of 1994, the "Summer Study in Engineering for High School Women" was held on the UMCP campus. The program encompassed two fundamental goals. The first goal was to expose promising young women to college level engineering study while they were still in high school so that they would have the opportunity to determine whether they want to pursue engineering as their field of study in college. The second goal was to provide a positive learning experience that would foster the students' self-confidence. Together the goals were designed to help young women believe that they can make significant contributions to the field of engineering

In order to meet the first goal, the program was designed to teach introductory engineering principles through an experiential learning process. Fundamental concepts were conveyed through hands-on design projects, field trips, and laboratory work. In order to meet the second goal, the program included female role models who offered genuine examples of successful careers in engineering, a critical mass of peers who shared similar aspirations to become engineers, and a sense of community to sustain students emotionally and academically. Ultimately, the program was designed to create a unique learning community for students to take risks, challenge themselves, and develop confidence in their ability to pursue a career in engineering.

Evaluation of the program demonstrated that it was comprehensive and successfully met its goals. The majority of the participants reported that they had gained a greater understanding of what engineering is, what engineers do, and their career options in the field of engineering. The majority also reported an increase in self-confidence. Thus, the program successfully provided a meaningful and positive learning experience for 30 high school women that ultimately enhanced their knowledge of engineering and their self-confidence in becoming an engineer.

Introduction

Research has indicated that the probability of women losing interest in science and engineering increases as they progress through their academic education ("Students Mentoring," 1992). The transition between high school and college is a crucial point where many young women engaged in the applied sciences and engineering cease their participation. In January 1994, for example, out of all the women entering college in the United States, only 2.9% planned to major in engineering (Blaisdell, 1994). This phenomenon, termed the pipeline model, underscores the need to bridge the gap between secondary school and higher education. Thus, early intervention is needed to maintain young women's interest in engineering and the applied sciences as well as to foster their self-confidence in pursuing a career in engineering.

In response to this need, in the summer of 1994, the A. James Clark School of Engineering at the University of Maryland at College Park (UMCP) and the Maryland Space Grant Consortium implemented a six-week summer program for young women who just completed their junior year in high school. The 1994 "Summer Study in Engineering Program for High School Women" was held from July 17 to August 26, 1994 at UMCP. Thirty women attended the six-week academic program and enrolled in two college level courses. The curriculum was designed to teach female high school students introductory engineering principles through an experiential learning process. Upon successful completion of the program, students earned six credits towards their college degree.

The following report is an evaluation of this pre-college engineering program for high school women. First, the report provides a description of the program goals, the recruitment and selection process, and the three facets of the program (i.e., academic, parental, and social). Secondly, a description of the evaluation method and results are provided.

Program Goals

As stated in the 1994 program brochure, one of the primary goals of the 1994 "Summer Study in Engineering for High School Women" was to expose promising young women to college level engineering study while they were still in high school so that they would have the opportunity to determine whether they want to pursue engineering as their field of study in college. The program's second goal was to provide a positive learning experience that would foster the students' self-confidence. Together the goals were designed to help young women believe that they can make significant contributions to the field of engineering.

Recruiting Women Students

Research has shown that intervention strategies implemented prior to the transition between high school and college are highly effective in recruiting women into engineering. Two follow-up studies were conducted in 1980 and 1983 of 350 women who participated in the six-week summer program during the late 1970s. The study determined that 70% of the women subsequently pursued careers in science and engineering (Berman, 1994). In an effort to continue such important interventions, the "Summer Study in Engineering for High School Women" targeted young women who were entering their senior year in high school and were in the process of choosing a college major.

In order to recruit qualified applicants, brochures were sent to high schools in Maryland, Northern Virginia, Washington D.C., Pennsylvania, New Jersey, and New York. Seventy-nine percent of participants reported that they had learned about the program through resources at their high school: 50% from their school guidance department and 29% from a science teacher. Students also indicated that they learned about the program from other sources: parents (4%),

publications (i.e., "Summer Search 1994") (8%), staff at the University of Maryland (5%), and friends (4%).

Ninety-one students from across the United States applied to the program. Thirty (33%) of the applicants were accepted. Admission was based on the student's high school grade point average, standardized test scores, a letter of recommendation (from a teacher, counselor and principal), and a personal statement. Students were selected based on criteria which included both student qualifications (i.e., academic performance in high school, motivation and interest in math and science, and willingness to meet new challenges) and issues of diversity (i.e., the distribution of the students' nationality, home county, and high school).

Of the students selected for the program, the mean S.A.T. math test score was 640 and mean S.A.T. verbal test score was 570. The mean high school grade point average of the participants was 3.63. The majority of the applicants selected for the program had completed mathematics courses in the following areas: algebra I, algebra II, trigonometry, geometry, and precalculus or calculus. In addition, twenty-five (83%) of the students were from Maryland while the remaining five (17%) were from states including Virginia, New Jersey, Pennsylvania, Illinois, and Connecticut. Students selected from Maryland were from the following counties: Anne Arundel, Baltimore, Cecil, Frederick, Howard, Montgomery, Prince George's, and Wicomoco. Finally, the program included students from traditionally underrepresented groups in engineering: 20% African-American (6), 17% Asian-American (5), 3% Hispanic-American (1), and 10% other (3). The remaining 50% of participants were Caucasian (15).

Program Structure

Women high school students who enter the summer program often come from their high school courses with a strong fundamental base in the basic math and science principles but lack knowledge of how these skills can be applied within the engineering discipline. The majority of students do not know what engineers do. As a result, many are not aware that engineering is a viable career path that allows them to utilize their skills in multiple creative and challenging ways.

In order to address this dilemma, the pre-college program was designed to expose students to the different disciplines within the field of engineering. During the six weeks, the students completed two college-level academic courses, "Introductory to Engineering Design" (ENES100) and "The World of Engineering" (ENES 121W), which provided them with an opportunity to develop an understanding of the fundamental principles of engineering. Through a wide range of learning activities (laboratory work, field trips, team design project, and computer classes), students were engaged in an active process of enhancing their ability to apply their skills, solve problems, and work with others.

During the course of the summer, the students were challenged to take risks and gain trust in their own ability. Thus, students needed a supportive learning enviornment which encouraged them to challenge themselves. Based on the work of Miller (1993), who examined the essential component of a encouraging learning environment for female students, the following elements were included in the six-week program: female role models who offered genuine examples of successful careers in engineering, a critical mass of peers who shared similar aspirations to become engineers, and a sense of community to sustain students emotionally and academically.

The program included an academic program, a parental program, and a social/residential program. The following section summarizes these three components of the pre-college program.

Academic Program

The academic program included two college-level courses, "Introduction to Engineering Design" (ENES 100) and "The World of Engineering" (ENES 121W). The engineering design course, "Introduction to Engineering Design" (ENES 100), introduced students to the fundamental principles and concepts of engineering science. The curriculum included course work on engineering principles (i.e., free body diagrams, mechanical equilibrium analysis, material selection and engineering drawing), computer skills, and a design project. Students were introduced to concepts on how to apply computer software programs (i.e., WordPerfect 5.1, QuatroPro, and Autosketch-Tutorial 3.0) to solve engineering problems.

The course curriculum was based on a project realization approach where students designed and manufactured a human powered water pump. Students were organized into five teams of six students. Each group worked as a team to design the pump by applying concepts of engineering acquired from class lectures. Computer programs were used to prepare the design documents of their team pump. Students were required to keep journals of their team meetings. In addition, teams were expected to work collaboratively on presenting their preliminary design projects and their final design package.

As outlined in the course syllabus for the course, "The World of Engineering" (ENES 121W), "the primary objective of this course is to demonstrate the role of scientific and mathematical principles in the creation of engineering design solutions." This was accomplished by a curriculum that included lab demonstrations, hands-on learning, computer simulations, and video presentations. There were eight laboratory demonstrations which introduced the students

to the various engineering disciplines (i.e., Aerospace, Civil, Electrical, Fire Protection, and Mechanical Engineering). The topics addressed in the laboratory demonstrations covered a wide range including the following: resolution of forces, fire hazard analysis, numerically controlled machining, ground water hydrology, and hazardous waste clean-up.

In order to provide students with an opportunity to interact with practicing engineers and develop an understanding of the application of fundamental theories, students made site visits to the National Institute of Standards and Technology and the John Hopkins Physics Laboratory. In addition, students were able to hone their writing skills by completing assigned lab reports for lab experiments and site visits. Finally, a female physicist from John Hopkins Applied Laboratory spoke to the students on current career topics for women in engineering

Parental Program

Parents were invited to actively participate in their child's experience. They were given the opportunity to visit the campus and to attend an orientation at the beginning of the program. In addition, they were encouraged to attend their daughter's presentation of the preliminary design and the final demonstration of the human powered water pumps.

Social/Residential Program.

Throughout the six weeks, all 30 students lived in six apartments on the UMCP campus. Each student had her own bedroom in a suite with four other members of the program. The program's student advisor and resident assistant, lived with the students in the residence hall. Social activities were organized by the resident assistant including a celebration dinner which was held following the mid-semester presentation of project designs. Other social opportunities were offered to the students (i.e., the use of gym facilities and free tickets to a local amusement park).

Evaluation

In order to assess the quality and effectiveness of the program, the program evaluation included both a focus group and a survey. All thirty students participated in one ninety-minute focus group in the fourth week of the program. The following topics were discussed: (1) students' present level of interest in engineering, compared with their interest at the beginning of the program, (2) what students found most valuable about the program, and (3) suggestions for improving the program for next year. In addition, a survey[1] was completed on the final day by 28 (93%) students. All of the survey questions were based on a five-point Likert Scale (i.e., 1 = Poor and 5 = Excellent). The three types of scales included in the evaluation were: poor to excellent, strongly disagree to strongly agree, and very low to very high.

The following summary is an evaluation of the program's efforts to meet the two goals of the six-week summer program: (1) to expose promising young women to college level engineering study while they were still in high school so that they would have the opportunity to determine whether they want to pursue engineering as their field of study in college and (2) to provide a positive learning experience that would build the students' self-confidence to become an engineer.

Program Goal One: To Expose High School Women to the World of Engineering

In order to successfully meet the program goal of exposing high school women to the world of engineering, students completed two academic courses: "Introduction to Engineering Design" (ENES 100) and "The World of Engineering" (ENES 121W). The courses included comprehensive coursework which exposed students to the expectations of an undergraduate engineering curriculum and the daily tasks of a practicing engineer. For example, students had

[1]Due to rounding, item percentages may not add up to 100%.

an opportunity to design, assemble, and test a human powered water pump, to master computer software, to complete labs in various engineering disciplines, and to develop skills in writing lab reports. In essence, the courses were designed to encourage students to gain a greater understanding of what engineering is and what engineers can do. In addition, the courses were intended to expose the students to the multiple possibilities within an engineering career and ultimately encourage them to consider engineering as a possible and viable career option.

Students' Responses to ENES 100 (Introduction to Engineering Design). When students were asked to respond to whether the hands-on project of designing the human powered water pump affected their learning, 97% reported that it had a positive or very positive influence on their learning. Only 4% of the students reported that the hands-on approach had a very negative influence (mean = 4.18 and standard deviation .77). One student commented in the survey: "I enjoy hands-on activities because that way I feel more involved and can better understand what I am doing." Another student added, "It made the learning experience so much richer and helped me to understand the material." Finally, a third student reported, "I've learned so much from our pump construction. If it were a lecture-type class, it would not have made the program special." Some students elaborated on this topic in the focus group. One student stated, "I really enjoyed the program. I liked applying things to practical uses, and I just enjoyed everything we had done. It makes me feel that I am using what I learned and even what I am learning now."

Students' Responses to ENES 121W (The World of Engineering). In the final written survey, all of the students reported that lab demonstrations and site visits included in the curriculum provided positive learning experiences. During the formal focus group discussion, students described the significant impact of the site visits on their experience. One student commented, "I liked the field trip at NIST. It allowed us to talk to actual engineers who were in

the field." Another student added, "I think that the visits were helpful to actually see people and talk with them about what they do. It helped me to see equipment they made. I asked them what would be a good major, and I got advice that was helpful."

Working in Teams. When students were asked how the team approach to engineering design affected their learning, 89% reported that the team approach had a positive or very positive influence on their learning experience, 4% reported not much influence, and 4% reported a negative influence (mean = 4.19 and standard deviation .66). Student comments on the survey included: "I think it gave a good overview on what life is really like since in jobs, people do work in groups." Another student commented, "Despite minor problems, working in a group gives new insight and ideas that an individual cannot see. It helped me to learn how to cooperate and compromise."

Increased Knowledge. The majority (82%) of students strongly agreed or agreed that based on their experience in the program, they had a better understanding of what engineering is and what an engineer can do. Seven percent of the students reported that they were neutral and 11% disagreed or strongly disagreed (mean = 4.07 and standard deviation = 1.05). Most students (79%) also agreed or strongly agreed with the statement that they had a better understanding of how engineering is used in the "real world." Eighteen percent were neutral, and 4% strongly disagreed (mean = 4.07 and standard deviation = .94). In addition, 79% of the students indicated that they strongly agreed or agreed that they had more knowledge about the types of career choices they will have in engineering. Fourteen percent were neutral, and 8% disagreed or strongly disagreed (mean = 3.96 and standard deviation = .96).

Career Choices. When asked to determine the likelihood of considering engineering as a college major, 68% reported that it was very high. Eleven percent predicted that there was not

much likelihood (mean = 3.70 and standard deviation 1.30). Students discussed in the focus group the important role the program played in helping them explore different career choices in engineering. One student stated,

> I didn't think I was going to like [engineering] so I didn't think I was going to want to be an engineer, but seeing all the different options is exciting. You know how we get a little overview of everything. That has made me kind of interested, and it tells me that there is more than just using a jigsaw to engineering. I like it now.

Another student commented,

> I came here just to see if maybe I would major in biomedical engineering or something like that. [The program] has kind of helped me to define what I do and don't want to do. It has kind of told me what engineering is really all about. It helped me gain an interest in biomedical engineering.

Program Goal Two: To Provide a Positive Learning Experience That Enhances Students' Confidence.

In order to meet the second goal of the program to provide a postive learning experience that enhances students' confidence, the program attempted to foster a supportive learning environment. According to Miller (1993), the basic elements needed to build and maintain a supportive learning enviornment for women studying engineering include the following: role models who offered genuine examples of successful careers in engineering, a critical mass of peers who share similar aspirations to become engineers, and a sense of community to sustain students emotionally and academically. Ultimately, these elements can create a unique learning community for students to take risks, challenge themselves, and develop confidence in their ability to pursue a career in engineering.

Female role models. The pre-college women's engineering program included various role models from various backgrounds, disciplines, and stages in their careers for the students to interact with and learn from. The lab instructor was a female engineering graduate student at UMCP, and the camp resident counselor and teaching fellow were female engineering students in the undergraduate program at UMCP. The lab assistant was an engineering student from Paris, France. The program guest speaker was a female engineer from the Applied Physics Lab at Johns Hopkins.

Inclusion of such a wide range of role models had a positive influence on the students experience; 78% of the students reported that working with women engineers had a positive or very positive influence on their interest in engineering (mean = 4.00 and standard deviation = .62). In the written comments of the survey, one student wrote "The female instructor and guest speaker were great models - both balance a career and a life and love engineering."

A critical mass of like-minded peers who share similar aspirations to become engineers. The program included a "critical mass" (30% or higher) of young women interested in engineering. When asked to indicate their reasons for attending the program, 93% indicated that their personal interest and ability in engineering had a significant impact on their decision. One student explained the importance of being with peers who have the same aspirations, "I like the fact that there are so many other people who are all interested in engineering so you don't feel like a nerd. I am in a science and engineering program at school but people there are like 'You, be an engineer? What?' Here we are all the same."

The majority of students reported that being with female peers had a positive or very positive effect on their learning experience. One student stated in the focus group, "The good thing about this program is that there is a lot of support for women in engineering. In my physics

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class this year there were only six girls out of thirty people." Another student responded to this comment by adding, " I like a class with all girls. I don't feel pressure to not ask 'brainy questions.'"

Community among students to sustain them emotionally and academically. Students explained that the relationships developed within teams were maintained outside of the classroom. Many students revealed in the focus group that there was a unique sense of community that existed among the students. One student explained,

> I think it is neat because in my high school ...everyone is competing to be number one. Here it seems like everyone is working together to help each other out. I think the pump project with the group has really happened because everyone is trying to help each other. I like that a lot better.

One of the most important arenas for students to build a connection with one another was in the residence housing. Students were asked to rate their overall experience of living on campus. Eighty-five percent of the students stated that the quality of their experience was high or very high (mean = 4.21 and standard deviation = .79). One student illustrated her appreciation for the on-campus living experience, "I like that everybody must live here. I have gotten to know people better in four weeks than it took me to know some of my really good friends in school. "

Increase in self-confidence. Most students indicated that based on their experience in the program, they felt more confident in their engineering skills (68% strongly agreed or agreed, 18% were neutral, and 14% disagreed or strongly disagreed, mean = 3.57 and standard deviation = 1.03). A similar pattern was revealed when students were asked if having completed the program, they felt more confident in their ability to be an engineer. More than half of the

students strongly agreed or agreed. One student stated in the focus group, "I like the way we learned about computer programs. Before I was here, I never used any computers at all. I feel like I will get a head start on college so I can feel more confident."

Students asserted that their increased self-confidence extended beyond the classroom. One student explained in the focus group,

I feel more aware of myself... It just really helps me feel more confident about myself. To know that I am really going to be something and I am really going to be working for something helps me to feel worth more.

Conclusion

Evaluation of the six-week "1994 Summer Study In Engineering for High School Women Program" demonstrated that it was highly comprehensive and successfully met its goals. Results of the survey and focus group indicated that the majority of the students gained a greater understanding of what engineering is, what engineers do, and knowledge about the various career within the field of engineering. In addition, the majority experienced an increase in their self-confidence to puruse a career in engineering.

The high quality of the program was also demonstrated in the students' rating of the program. When students were asked to rate the overall program, 90% reported that it was good to excellent (mean = 4.3 and standard deviation = .65). In addition, 96% of all participants stated that they would recommend the program to other students. On the final day, more than one quarter of all the students (26%), reported that they had already recommended the program to another person.

In conclusion, the program provided a valuable learning experience for 30 high school women. The supportive nature of the program and the comprehensive curriculum invited

students to explore and challenge themselves and as a result, learn more about the field of engineering as well as their own ability to become an engineer. Thus, the "Summer Study in Engineering for High School Women" played an indispensable role in recruiting and retaining young women in the field of engineering.

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